Senior Thesis

Reconnaissance Survey of Groundwater Resources in Northwest Franklin County and Southeast Union County

by
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Approved by:

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Summary

This study was conducted to review and determine the available groundwater resources in northwestern Franklin County and southeast Union County. Increasing population growth and demand for water will make it necessary for the suburban communities northwest of Columbus to provide a larger share of their own municipal water supplies.

Data were compiled from one hundred and seventy-three well logs on file at the Ohio Department of Natural Resources Division of Water. One hundred and fifty-eight (91 percent) of the wells were completed into the carbonate bedrock aquifer system, whereas fifteen wells (9 percent) were completed into the glacial-drift aquifer. Pertinent information was compiled from the logs such as; the driller's lithologic log, static water levels and where possible, the pumping rate and drawdown from well production tests. This information was used to constuct a top-of-bedrock map, a composite potentiometric surface, and a drift-thickness map. These maps in conjunction with published material were used to interpret and determine the possible locations of potential groundwater sources for municipal use.

I. Introduction

The northwest section of Franklin County is one of the fastest growing areas in the entire country. The City of Dublin has grown from a village of 552 people in 1960, to a city of 12,321 people in 1988. In the last nine years the population has increased 320 percent (MORPC, 1989).

The demand for water also has followed this increasing trend. Water usage in Dublin has increased from 0.88 mgd (million gallons per day) in 1985, to 1.64 mgd in 1988 (fig.1).

Presently the City of Columbus provides water services to Dublin, but as demand continues to grow, Columbus may be unable or unwilling to supply water to Dublin.

As this suburban area grows the demands for water are increased disproportionately to older areas of Columbus. New housing developments require more water than established residential areas due to increased usage for new lawns, and the demand of large, multi-family housing complexes. A conservative estimate by the Columbus Division of Water, estimates the average customer in Dublin will require 314 gallons per day in 1989.

The water demand for the northwest suburbs can be supplied from two sources; the Scioto River and the regional carbonate-bedrock aquifer that underlies this area. It is my contention that if the chemical quality of the groundwater can be maintained, it is the most reliable and best supply of quality water. Ground water, as compared to surface water, is not as susceptable to seasonal variations in precipitation causing drought and from contamination from surface pollution sources.

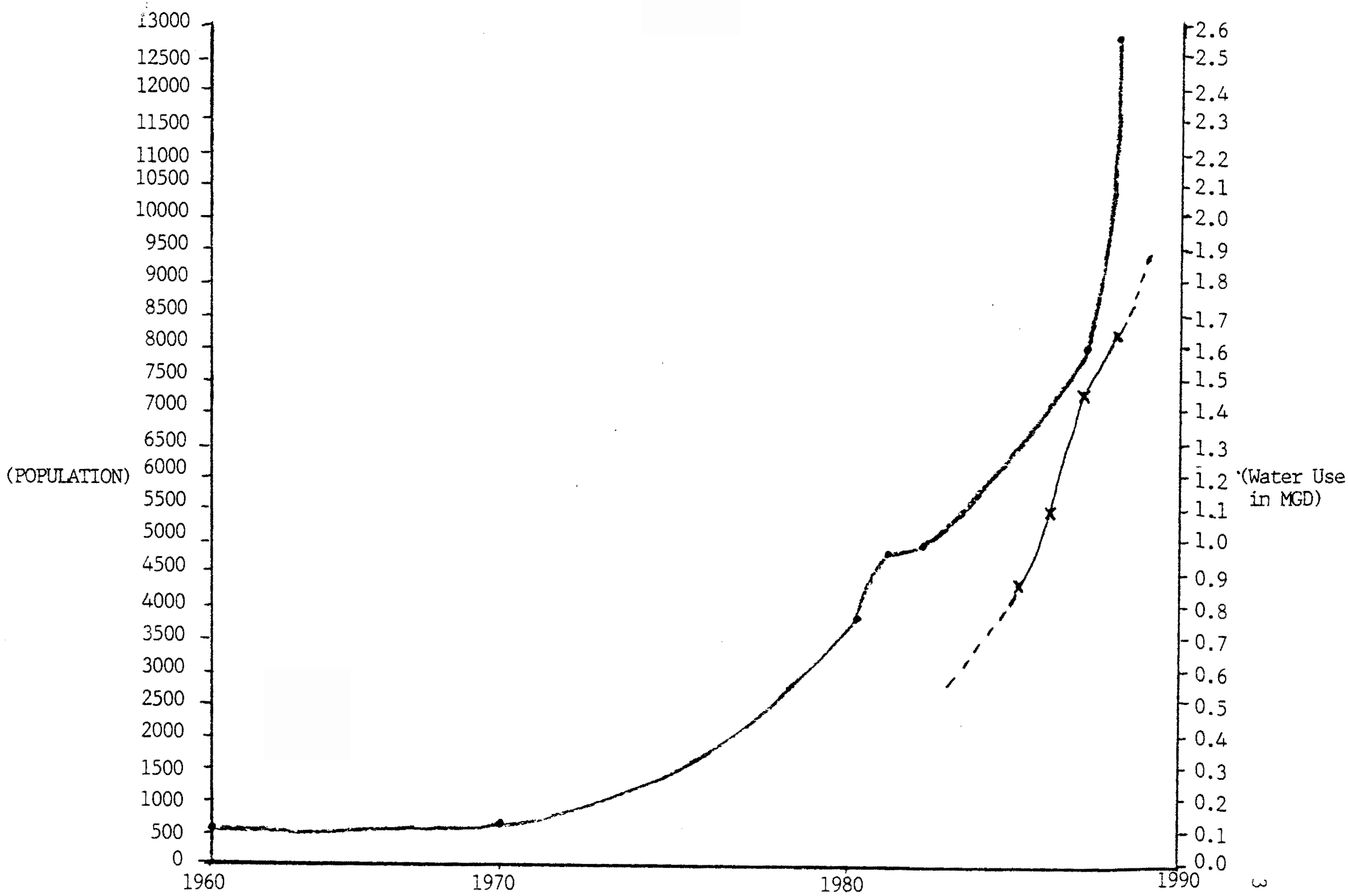


Fig. 1. Water Use and Population Trends in Dublin, Ohio
(Statistics from MORPC and Columbus Division of Water)

• Yearly Population

x Daily Water Use (Million Gallons per Day)

The Study Area

The study area encompasses all of Washington Township in Franklin County and the Southeastern section of Jerome Township in Union County (plate 1). This area is bounded by the Scioto River on the east, Hayden Run Road on the south, the Madison County line on the west, and the Delaware County line extending into Union County on the north (plate 1). This represents an area of approximately 32 square miles.

Physiography and Topography

The study area is marked by low relief except for the steep slopes adjacent to the Scioto River. Till plains cover the majority of the area with the exception of the northern border where the Powell end moraine is present. The topography is nearly flat on the till plain and gently rolling on the end moraine.

The land surface is nearly void of geomorphic features except for small stream channels and drainages that flow eastward toward the Scioto River. The Scioto River valley on the eastern edge of the area, is narrow and runs in a north-south direction. The Powell end moraine extends into the area from the north and is bounded by the North Fork of Indian Run on it's southern edge.

Relief

The highest landsurface elevations occur in the northern part of the study area, in the vicinity of the Powell end moraine, where the elevation reaches 950 feet above sea level. The western part of the area generally has elevations above 940 feet. The lowest elevations is at the Scioto River at 740 feet. The maximum relief over the area is approximately 210 feet.

II. GENERAL GEOLOGY

Pleistocene Geology

Glaciers covered central Ohio during four different stages in the last million years. It is not certain if the first two stages in Illinoisan time covered all of Franklin County (Goldthwait, 1958). A pre-glacial valley is buried below the unconsolidated glacial drift and extends in a northeast to southwest direction in the central and western parts of the study area. According to Goldthwait (1958) fine sand found in the buried valley probably accumulated during Illinoisan time, which indicates glaciers from at least one of the first two glaciations did cover this area.

The Wisconsinan glaciations occurred in two stages. The first stage was about 50,000 years ago and the second stage was about 22,000 years ago (Goldthwait, 1958). The Scioto lobe was part of the last glaciation and was the largest ice tongue covering Ohio. It extended from Wyandote and Crawford counties to the north, to the edge of the Wisconsinan ice sheet in Ross, Farfield, and Licking counties in the southern part of the state. The Powell moraine marks the retreat of the last glacial advance about 16,000 years ago (Goldthwait, 1958).

Ground Moraine

Till comprises the major glacial landform in the study area, a broad extensive ground moraine. The ground-moraine surface is nearly flat and covers approximately ninty percent of the study area. The till consists of a heterogeneous mixture of 15 to 40 percent clay, 20 to 50 percent silt and 25 to 50 percent sand. Pebbles and boulders up to 5 feet in diameter have been found in the till (Goldthwait, 1958). Eighty percent of the pebbles are pure dolomite and are oriented in a general north-south direction. This is evidence that the glaciers advanced from the north where the prominent bedrock consists of dolomite.

In many locations the glacial drift contains lenses of sand and gravel. These lenses vary in thickness and areal extent. Well logs show the lenses to be as much as thirty feet thick. The sand and gravel lenses are considerbly more permeable than the surrounding silt and clay, and commonly are used as sources of groundwater for domestic use. Many of the domestic wells completed in the glacial aquifer are located on top of the buried pre-glacial valley in the west-central part of the study area. Well logs show the ground moraine thickness to be highly variable, from a thin veneer a few feet thick adjacent to the Scioto River, to over 220-feet thick in the buried valley (plate 2).

End Moraine

The Powell end moraine along the northern edge of the study area, forms a topographically higher, gently rolling and hummocky landform. The moraine can be observed when driving north on Route 745, north of Brand Road, by the gently rolling terrain. The end moraine is 20 to 50 feet higher than the surrounding ground-moraine surface.

The drift material consists mainly of till with a higher percentage of sand and gravel masses than the ground moraine till (Goldthwait, 1958). Well logs show the till to vary from 28 to 99 feet in thickness. The end moraine marks the edge of the last glaciation where the ice sheet stood stagnant for approximately one hundred years (Kovach and Baker, 1966). This last retreat occurred approximately 16,000 years ago.

Bedrock Surface and Buried Pre-Glacial Valley

Buried beneath the glacial drift lies a bedrock surface of low relief that is dissected by a broad river valley. Well logs were used to map the bedrock surface. The buried valley was clearly distinguishable in the north-central to west-central parts of the area (plate 3).

This historic river was a tributary of the pre-glacial Teays River system. The headwaters of this drainage were in the north-central part of the study area and flowed in a southwesterly direction into what is now Madison County. The river, eventually drained into the Groveport River, which was the largest tributary of the Teays system within Ohio (fig. 2). The Groveport River was close to 150 miles in length (Stout, and others, 1943). The bottom of the buried valley is around 700 feet above sea level and the maximum relief of the valley is 175 to 200 feet.

The bedrock surface is relatively flat except where it was dissected by drainages. Geomorphically, this area progressed from physiographic youth to old age by erosional cycles where valleys were carved and tributaries were incised into the bedrock. This cycle repeated itself on numerous occasions,

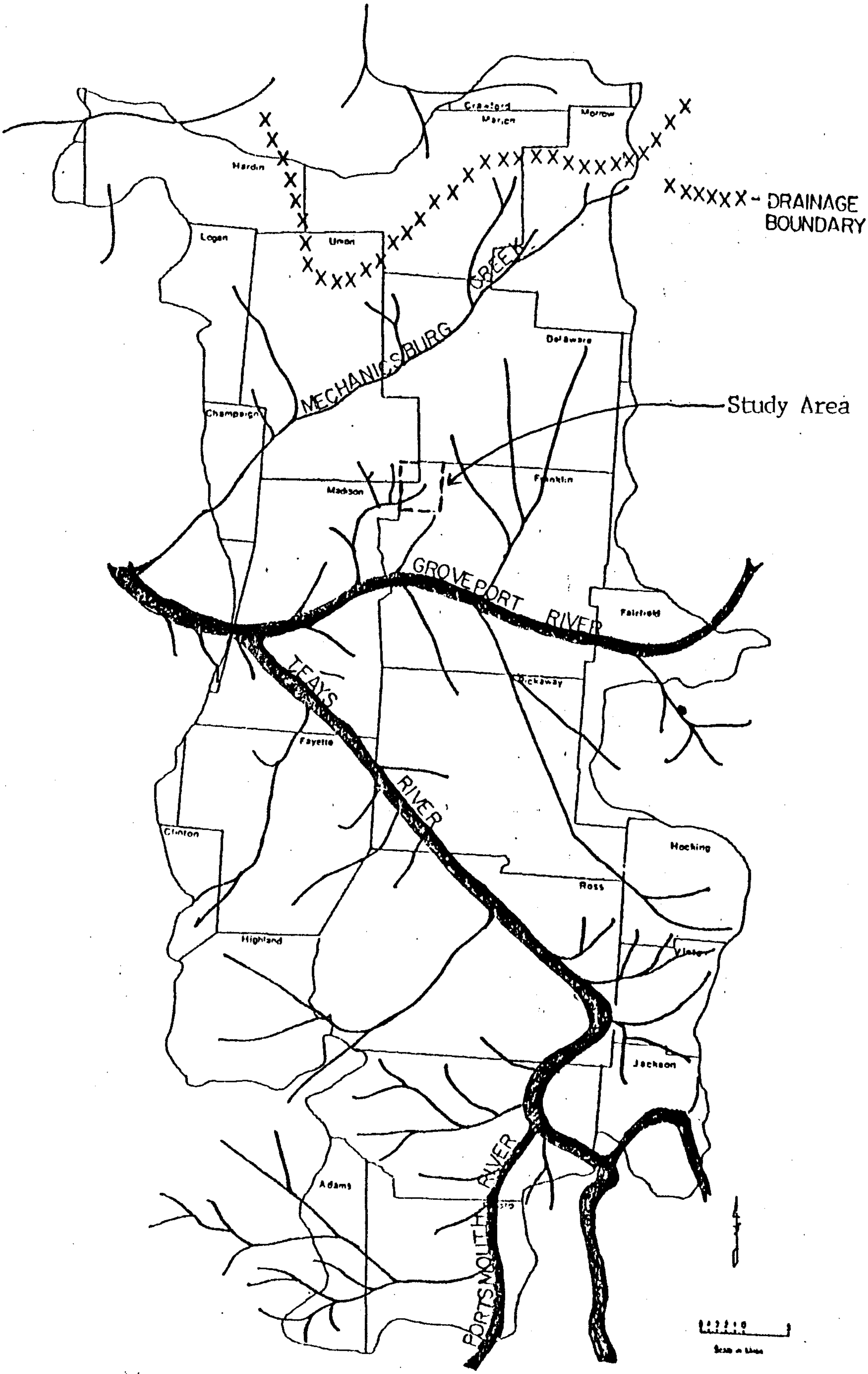


Figure 2. Teays Stage drainage in the Scioto River basin (after Stout et al., 1943).

with the area being reduced from a low plateau to a lower "older" surface before glaciation (Stauffer, 1911).

The Pleistocene glaciations had a lasting effect on the Teays drainage system. As glaciers encroached from the north, these valleys were broadened and the hilltops were rounded off. When the glaciers melted, the valleys were filled with till, outwash, and lenses of coarser material (figs. 3 & 4).

The highest elevation of the bedrock surface in the study area is 915 feet in Union County. The lowest elevation is 722 feet at well No. 203 in the center of the study area. (Because no wells were drilled into the bedrock in the middle of the buried valley, only an estimation could be made as to the elevation of the bedrock in this area.)

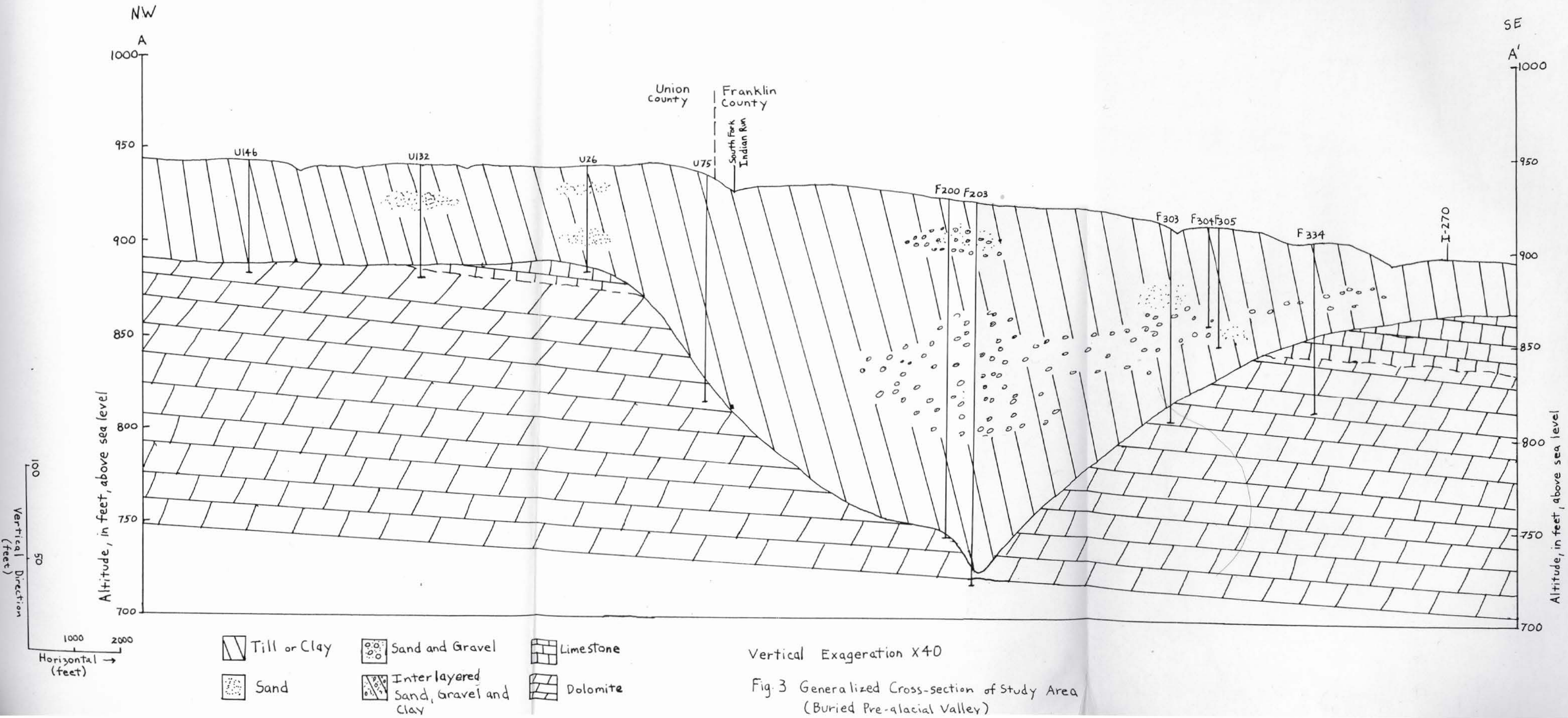
Bedrock Geology

Silurian System

Silurian strata crop out in the buried valley, but due to the thick cover of glacial drift, no outcrops are present at the land surface. The Silurian system consists of a thick series of massive limestones and dolomites, which are separated at the base by the Osgood Shale. Below the Silurian System lies undifferentiated Ordovician shales (fig. 5).

The upper part of the Brassfield Limestone is massive, extremely hard, and crystalline at the top. It is overlain by the Osgood Shale which is soft, calcareous and contains thin layers of dolomite.

The dolomites of the Lockport Dolomite and Bass Islands Group form the lower portion of the regional Silurian-Devonian



Vertical Exageration X40

Fig. 3 Generalized Cross-section of Study Area (Buried Pre-glacial Valley)

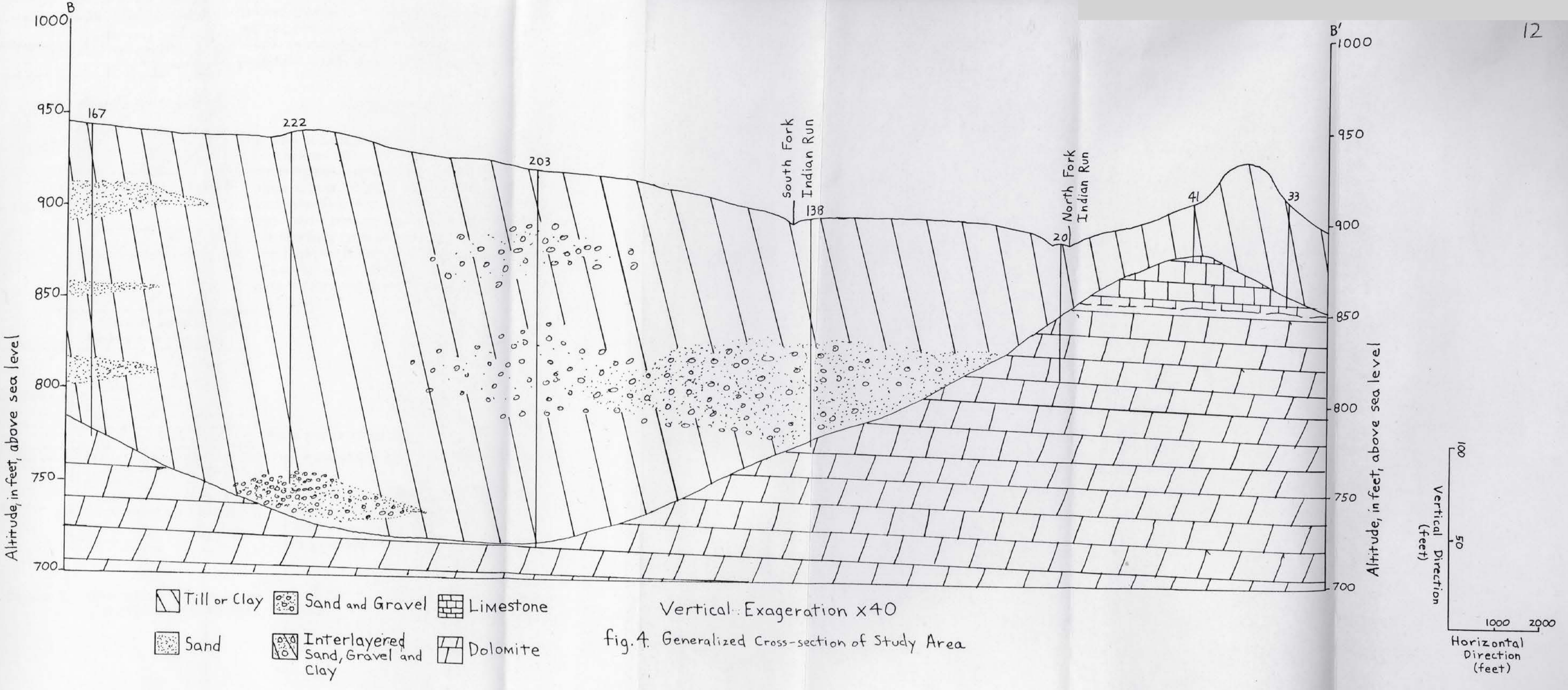


fig. 4. Generalized Cross-section of Study Area

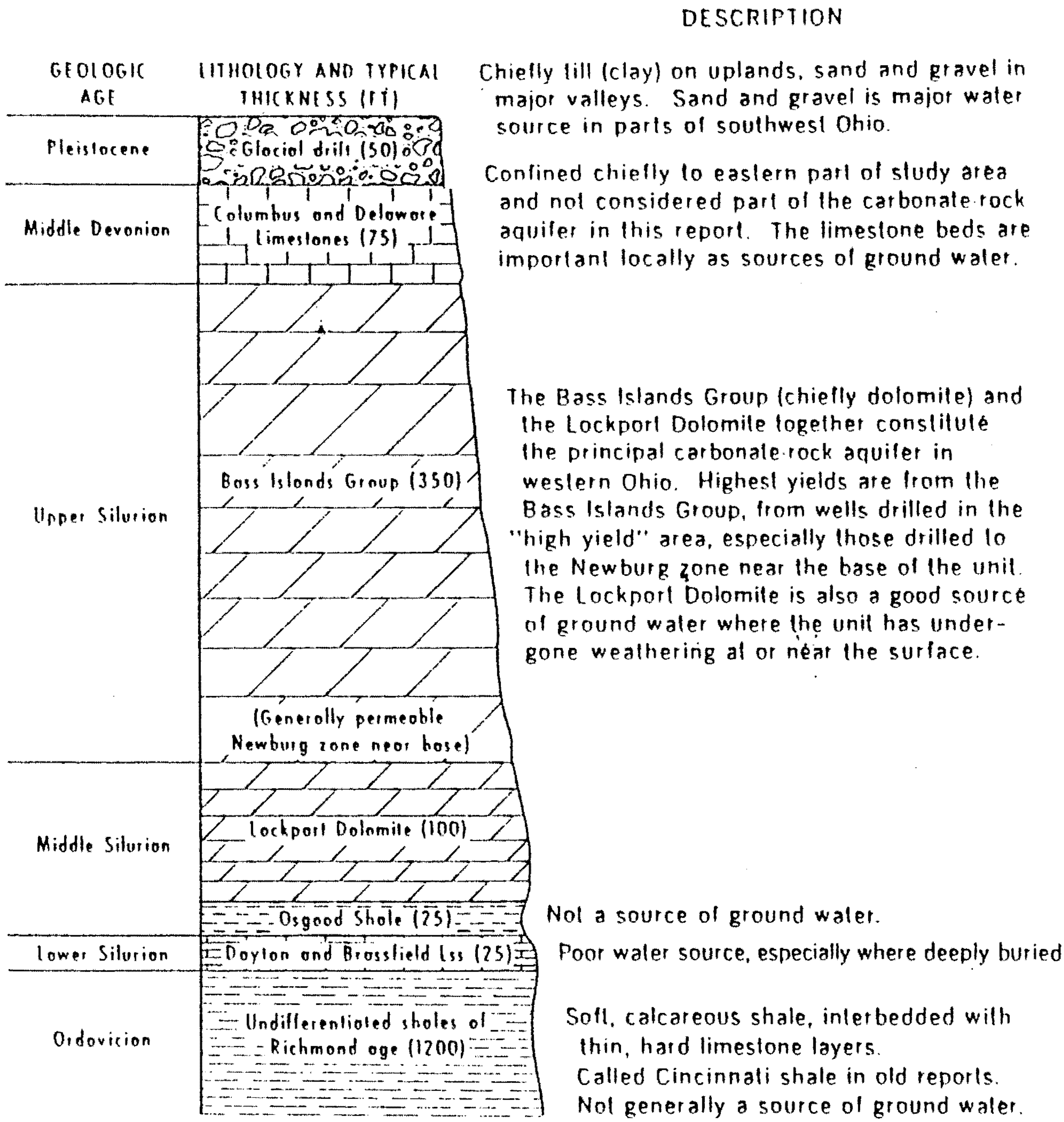


Figure 5. Generalized Geologic section of the Study Area.
(Modified from Norris, 1973)

Carbonate aquifer. The Lockport is a light gray to white, fine to coarsely grained, bedded, pure dolomite (Ukayli, 1978). The dip of these carbonate units is approximately 25 feet per mile (Norris and Fidler, 1973).

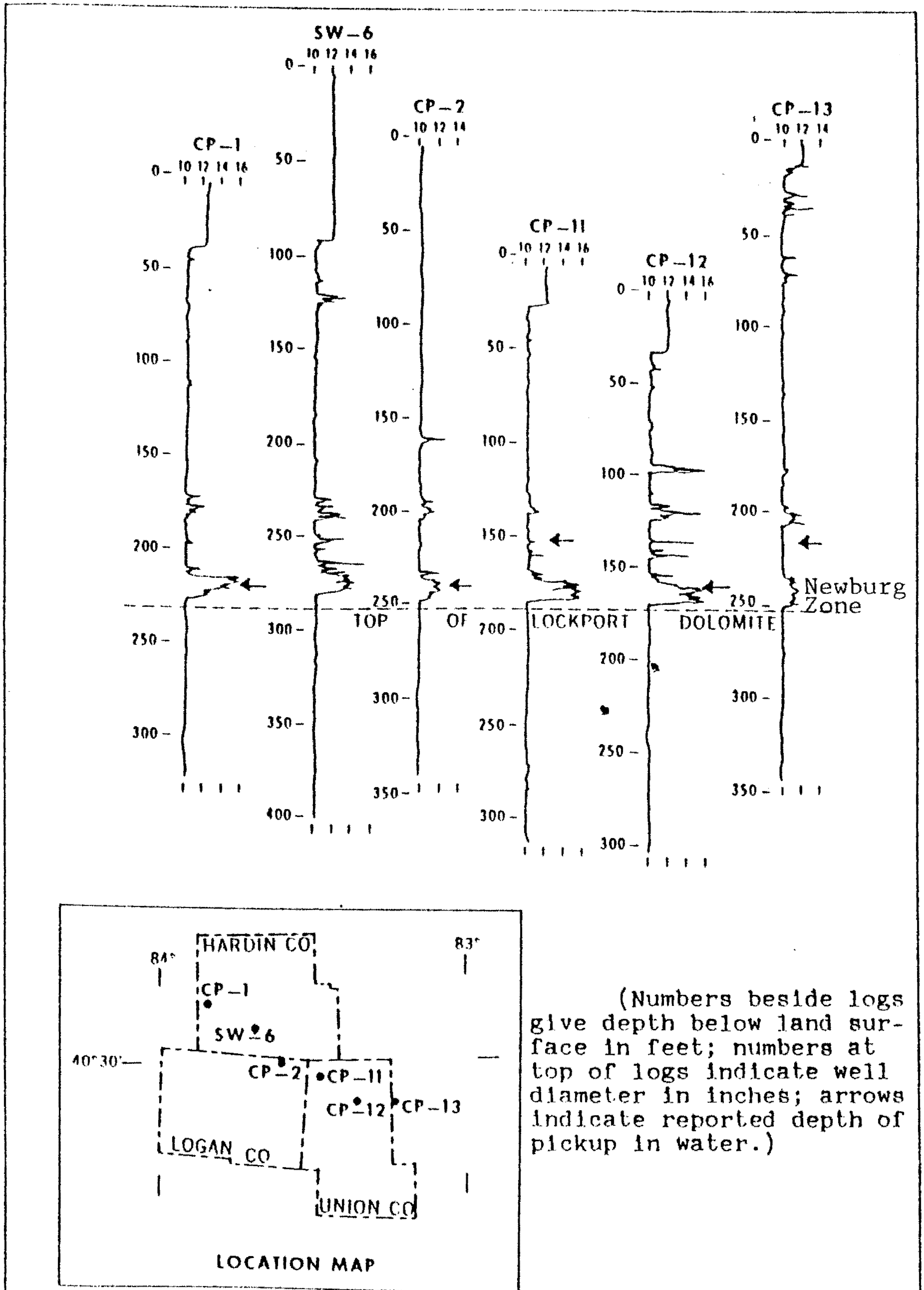
The Bass Islands Group consists of brown to bluish gray, medium bedded argillaceous dolomite that averages 350 feet in thickness and contains thin, randomly distributed beds of gypsum and anhydrite.

The Newburg zone is a hydrologically important section of the lower Bass Islands Group. This zone is about 10 to 15 feet thick and contains large cavities and solution channels (Ukayli, 1978). The cavities were formed by groundwater circulation when this stratum was at or near the land surface. The base of the Newburg zone lies 3 to 5 feet above the underlying Lockport Dolomite (fig. 6).

Devonian System

A major disconformity separates the Devonian and Silurian systems. This disconformity represents an extended erosional period during early Devonian time. The disconformity does not manifest itself at the land surface in the study area. Locally, the disconformity is recognized by a conglomerate that characterizes the base of the Columbus Limestone. Outcrops containing the disconformity can be seen along Big Darby Creek (Stauffer, 1911).

The lower section of the Columbus Limestone is a massive brown limestone containing a high percentage of magnesium. Orton (1878, p. 616) reported that in the Dublin area the limestone is 41 percent magnesium. The formation grades upwards into



(Numbers beside logs give depth below land surface in feet; numbers at top of logs indicate well diameter in inches; arrows indicate reported depth of pickup in water.)

Figure 6. --Caliper logs of selected wells in western Ohio showing cavity zone (Newburg) above the Lockport Dolomite. Datum is top of Lockport Dolomite. (From Norris, 1973)

a bluish-gray purer limestone, containing 81 to 93 percent calcium carbonate (Goldthwait, 1958). The Columbus Limestone is jointed, extremely fractured, and has visable bedding planes.

The Delaware Limestone conformably overlies the Columbus Limestone. This contact is marked by the abrupt change from the "pure" limestone at the top of the Columbus formation, to the argillaceous cherty blue limestone and calcareous brown shales of the Delaware formation.

The thickness of the Devonian Limestone in the study area was not directly determined, but interpolating from Goldthwaits' studies it probably ranges from 50 to 100 feet thick in the eastern part of the study area, to 0 to 50 feet thick in the western part.

III. HYDROGEOLOGY

Two aquifer systems are present in the study area: a shallow, low yielding glacial-drift aquifer and a high yielding, regional carbonate-bedrock aquifer. These two systems are hydraulically connected by vertical leakage.

Groundwater Resources in Glacial Deposits

The entire study area is covered by glacial drift which consists of clayey till containing randomly distributed lenses of sand and gravel. Well logs show some of the lenses in the buried valley to be over 30-feet thick and approximately 5,000 to 10,000 feet in lateral extent. These lenses can store large quantities of groundwater, but due to the low permeability of the sands, recovery is prolonged. Most of the wells completed in these lenses are only used for domestic purposes. Yields from these wells are relatively low with pumping rates ranging from 5 to 36 gpm(gallons per minute).

The wells completed in the glacial material range from 41 to 170 feet in depth. The quality of water recovered from these wells is good, but the water is hard. Hardness averages 386 ppm (parts per million) calcium content (Goldthwait, 1958). The majority of the wells completed in the glacial-drift aquifer are located in the buried valley where the drift reaches 220-feet in thickness and sand and gravel lenses are more numerous.

The glacial drift acts as a leaky "confining" layer for the underlying carbonate aquifer. Water leaks vertically into the carbonates acting as a source of recharge, except along the Scioto River valley where water discharges from the carbonate-bedrock aquifer upward into the glacial material. Where large sand and gravel lenses are present, recharge rates can be greatly increased. In addition, the quality of the water in the carbonate-bedrock aquifer can be enhanced by a reduction in hardness that results from infiltration of good quality water from the overlying glacial-drift aquifer.

The glacial aquifer contains adequate groundwater resources for domestic use, but not for municipal purposes. The largest contribution this aquifer plays on the regional hydrogeology is as a source of recharge for the underlying carbonate-bedrock aquifer.

Groundwater Resources in the Carbonate-Bedrock Aquifer

The regional carbonate-bedrock aquifer is a potential source for high yielding municipal wells. This flow system consists of hydraulically interconnected beds of Silurian and Devonian limestones and dolomites. Stratigraphically from oldest to youngest member the aquifer consists of; the Osgood shale which is a lower "confining" layer, the Lockport Dolomite, the Bass Islands Dolomite, the Columbus and Delaware limestones and glacial till which acts as an overlying leaky confining layer (fig. 5).

The major recharge area for the aquifer is a topographically high region in the western part of the state. This region is the drainage divide between the Miami and Scioto Rivers. The direction of regional groundwater flow corresponds with the dip of the carbonate beds which is approximately 25 feet per mile to the east. The potentiometric-surface map shows this easterly trend and the increasing hydraulic gradient in the vicinity of the Scioto River (plate 4).

Hydraulic Conductivity

The hydraulic conductivity of the carbonate formations is a result of solution by water moving through joints and bedding planes. Most of this transporting ability was developed in the geologic past by uplift of the Cincin~~n~~a~~t~~ti Arch, which caused erosion of younger strata and fracturing of the Silurian and Devonian carbonates. Norris (1973) states that solution was most active in beds that were in structurally higher areas and periodically emerged above sea level in the geologic past. The carbonates remained above sea level for varying amounts of time during which they were subject to groundwater circulation and solution (Norris and Fidler, 1973).

The lower Bass Islands group contains a zone of high hydraulic conductivity known as the Newburg zone. The strata has been defined by Norris (1973) by using caliper logs (fig. 6). The zone ranges in thickness from 10 to 15 feet and is found 3 to 5 feet above the Lockport Dolomite (Norris, 1973).

This zone developed as a result of lower water tables in pre-glacial time. These water levels were up to 200 feet lower than present day levels. As a result of lower base level secondary permeability developed in the lower parts of the carbonate system. As base level rose through geologic time to it's present level, groundwater had a chance to move through the full thickness of the carbonate aquifer and develop and enlarge solution openings (Norris, 1973).

Specific Capacity and Transmissivity

The study area is located within a high yield zone as defined by Norris (1973) (fig. 7). This area has wells with specific capacities ranging from 5.4 to 108 gpm/ foot of drawdown (gpm/ft). Pumping rates in this area averaged 665 gpm during pumping tests performed by the U.S. Geological Survey (USGS). A pumping test was performed in 1971 by the USGS at well CPBR-23 in Union County. This well is completed in the Bass Islands group at a depth of 355 feet. A specific capacity of 9.61 gpm/ft was calculated after correcting for well losses using a well-loss constant of 23 sec^2/ft^5. A pumping rate of 936,000 gpd was determined to be feasible at this well.

A transmissivity of 8,800 gpd/ft was calculated at this well. This value falls in the range of values calculated by the Ohio Division of Water at several test wells in the carbonate aquifer (Ukayli, 1978). The values ranged from 6,800 to 210,000 gpd/ft (Ukayli, 1978). This wide range of transmissivity values is due to the random distribution of fracture systems and solution channels.

Recharge to the Aquifer

Recharge to the aquifer is derived from two sources. Water entering the aquifer at the topographic divides to the west and vertical leakage through the overlying glacial drift. Water

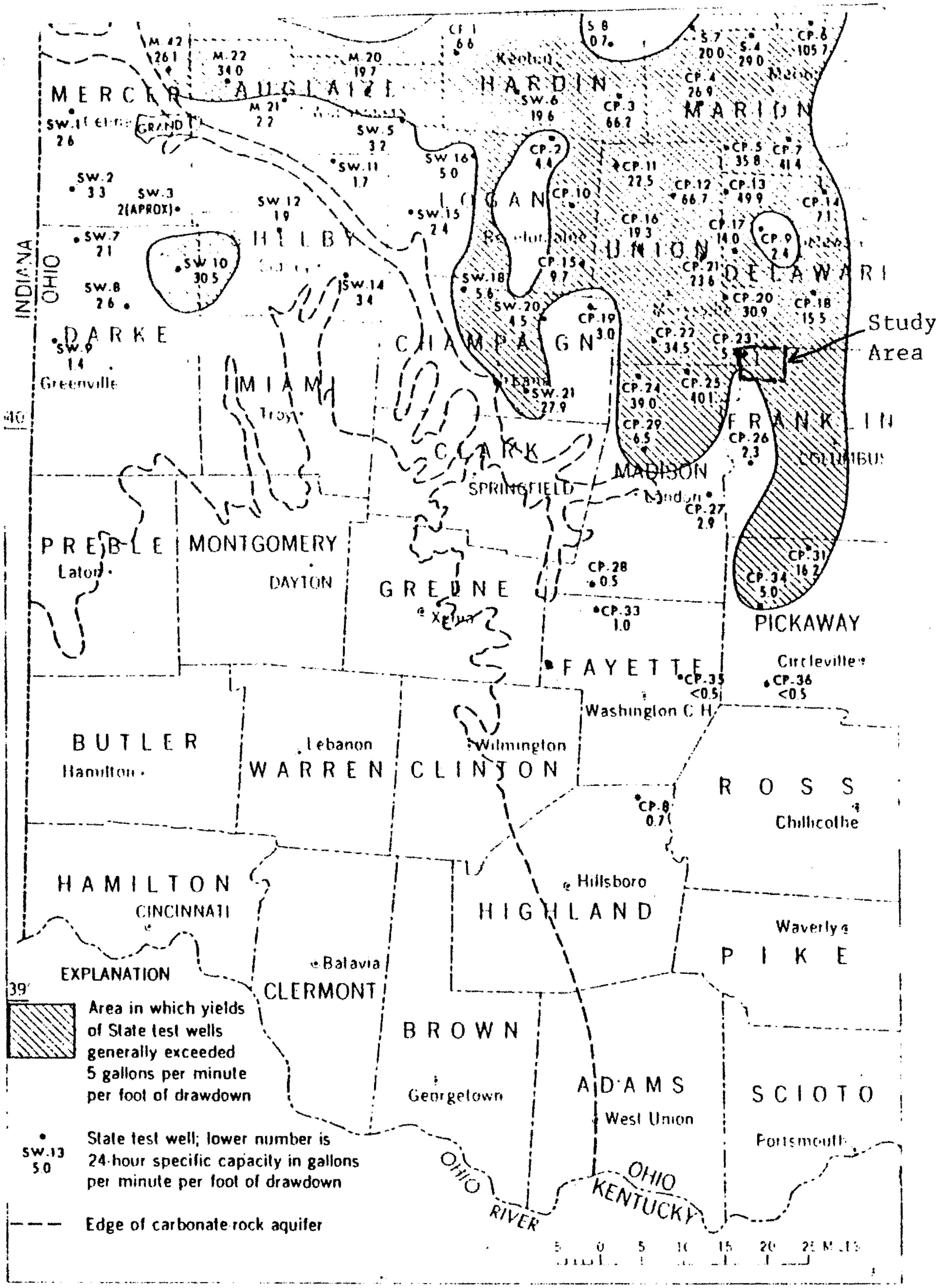


Figure 7. --Map of southwest Ohio showing area of high-yielding wells drilled in the carbonate-rock aquifer.
(Modified from Norris, 1973)

enters the aquifer in the recharge areas and flows in an easterly direction toward the Scioto River. This flow is controlled in large part by the regional dip of the bedrock.

A much larger percentage of recharge is derived by vertical leakage. The amount of recharge obtained from the overlying glacial deposits is dependent on the thickness and type of material present in the till. Recharge is highest in areas where the drift is thin or where it contains sand and gravel lenses.

Buried valleys have a signifigant impact on recharge rates. Most of the recharge into the Newburg zone occurs in areas where the zone crops out (Ukayli, 1978). Leakage from sand and gravel lenses in the buried valley flows into the fractures of the Newburg zone and contributes to the higher yields of this zone (Ukayli, 1978).

Chemical Composition of Groundwater

The chemical composition of groundwater is dependent on the mineral composition of the bedrock and the length of time the water is in the aquifer system. Regional flow has a large impact on the quality of the groundwater in the carbonate aquifer. The water in the system becomes progressively more mineralized as it moves down the potentiometric gradient (Norris, 1973). Norris (1973) tested wells in recharge, intermediate and discharge areas within the carbonate-bedrock aquifer and showed a progressive increase in calcium and total dissolved solids content. Calcium content averaged 88 mg/l in the recharge area, 125 mg/l in the intermediate area, and 323 mg/l in the discharge area. Total dissolved solids ranged from 435 mg/l to 715 mg/l to 1826 mg/l. These results clearly show the progressive change in the chemical quality of groundwater in various areas within the regional carbonate-bedrock aquifer. The USGS had water tested at well CBPR-23 and the hardness was found to be 440 mg/l and the total dissolved solids concentration was 488 mg/l. A well completed in the Bass Islands Group in the buried valley near Amlin, Ohio, produced similar water-quality results. Hardness was 429 ppm and total dissolved solids was 464 ppm. The water from these wells would be considered hard but with treatment it would be suitable for municipal supply.

IV. CONCLUSIONS

The regional carbonate aquifer has the potential to serve as a source of groundwater for the municipalities northwest of Columbus. The Newburg zone is an extremely permeable stratum within the Bass Islands Group. This zone lies about 400 feet below the land surface at the top of the Lockport Dolomite. This zone has the potential to supply over 1 million gallons of water per day per well.

A possible good location of high yielding wells would be beneath the buried valley sand and gravel lenses, completed into the Newburg zone. Yields may be high in this locality because of increased recharge produced by the infiltration of water from the overlying glacial deposits.

A more detailed study is needed to determine the location of the Newburg Zone in the study area. Detailed chemical analysis also is needed to determine water quality which could be poor in many locations because of the proximity to the discharge area. Overall the prospects are good that the increasing water demand of northwest Columbus can be met by the carbonate-bedrock aquifer. Further studies are needed to determine the feasability of such a large-scale water project.

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